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(54) **PROTECTION OF NON-VOLATILE MEMORY COMPONENT AGAINST DATA CORRUPTION DUE TO PHYSICAL SHOCK**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 277 days.

This patent is subject to a terminal disclaimer.

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(51) **Int. Cl.**
G06F 11/00 (2006.01)

(52) **U.S. Cl.** **714/22**; 714/24; 713/324; 713/340

(58) **Field of Classification Search** .... None
See application file for complete search history.

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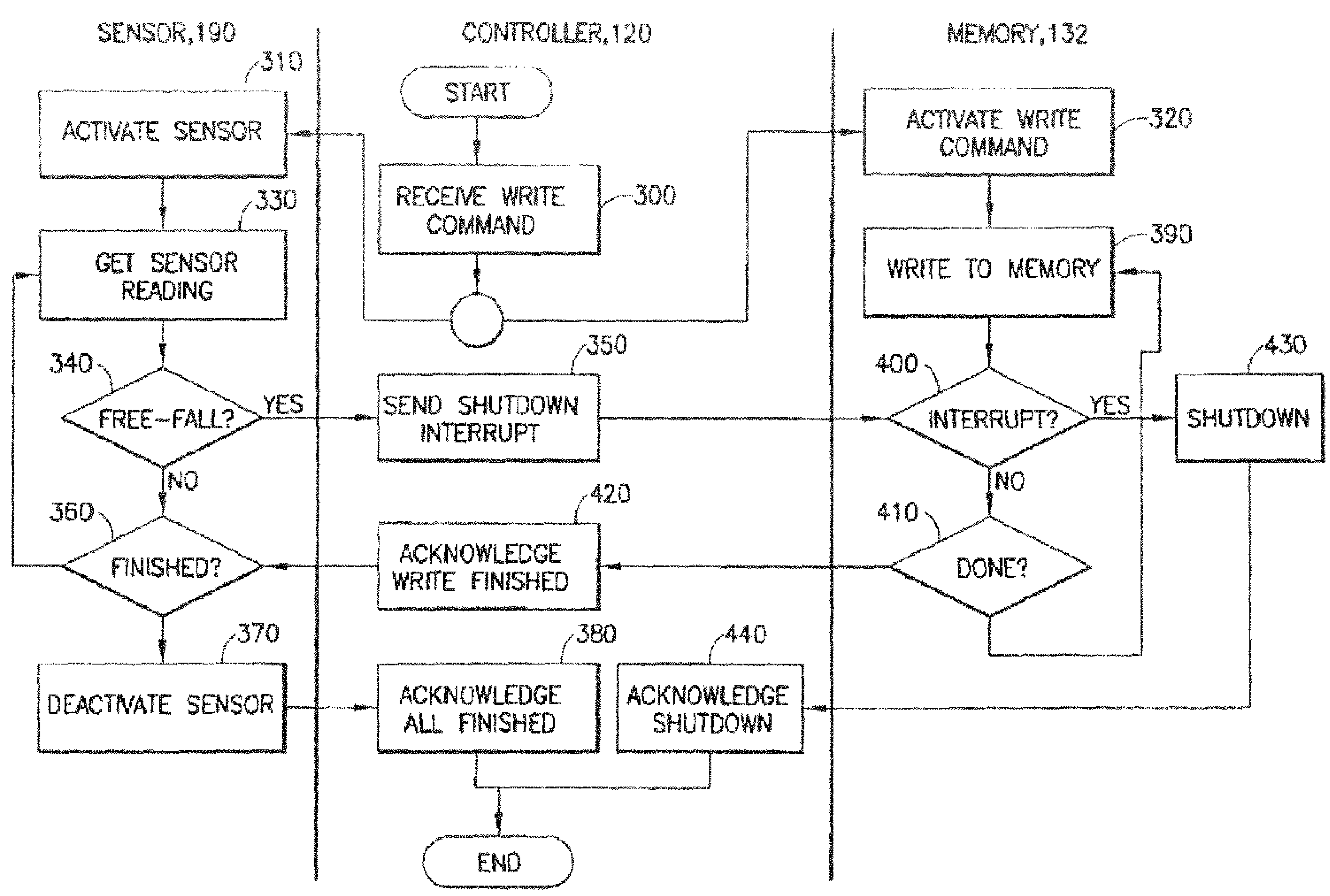
Primary Examiner — Yolanda L Wilson

(57) **ABSTRACT**

A device, a computer readable medium, and a method are provided. The device includes, but is not limited to, a sensor, a processor, a non-volatile memory, and a computer-readable medium. The computer-readable medium includes, but is not limited to, computer-readable instructions stored therein that, upon execution by the processor, perform operations comprising initiating a write operation of data to the non-volatile memory; during the initiated write operation, monitoring the sensor to determine if the electronic device is falling; and if the electronic device is determined to be falling, interrupting the initiated write operation and executing a non-volatile memory shutdown procedure.

26 Claims, 2 Drawing Sheets



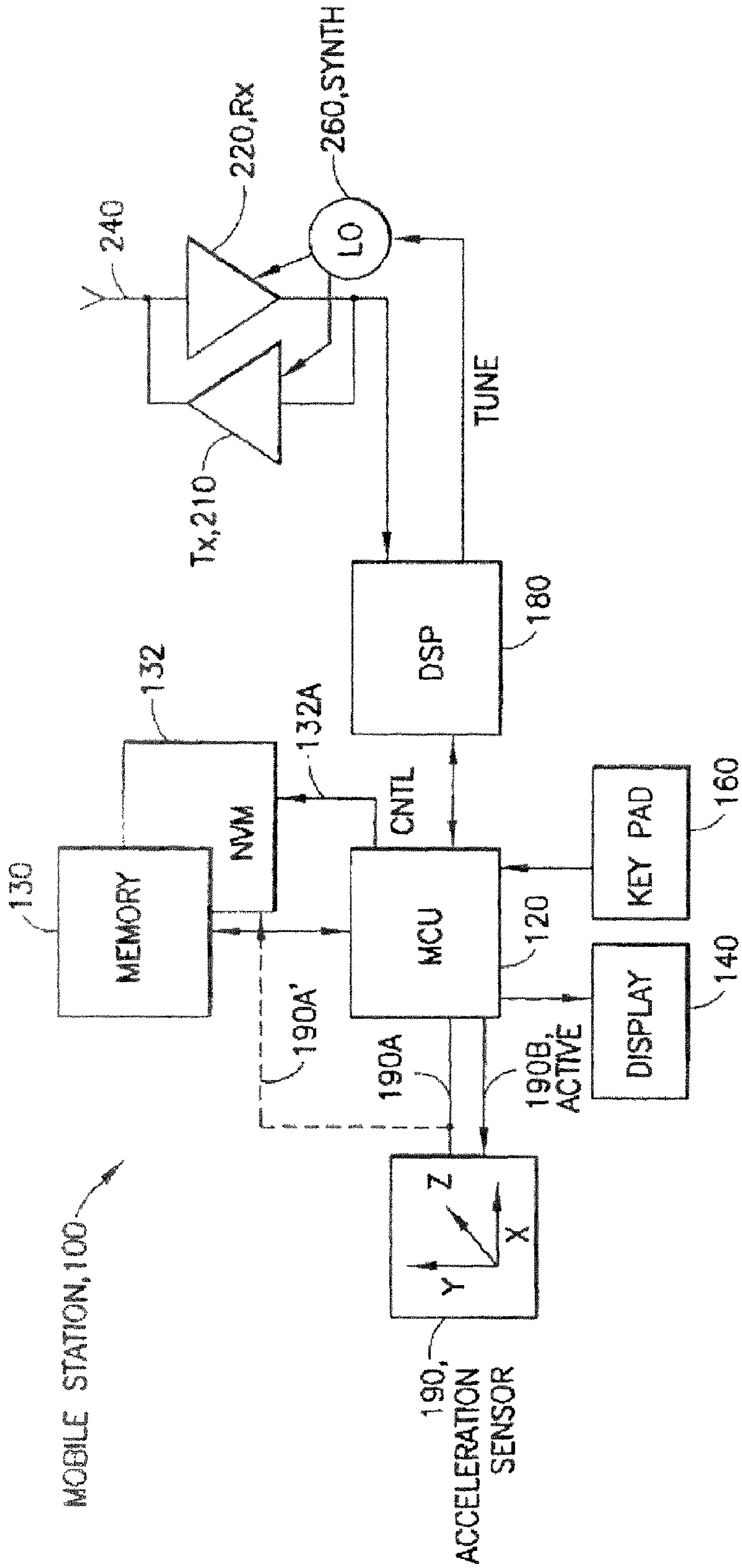

240
220,Rx
260,SYNTH
LO
Tx,210
TUNE
DSP
180
132
132A
NVM
CNTL
MEMORY
130
MCU
120
KEY PAD
160
DISPLAY
140
190A'
190A
190B, ACTIVE
MOBILE STATION,100
Z
Y
X
190, ACCELERATION SENSOR

FIG. 1

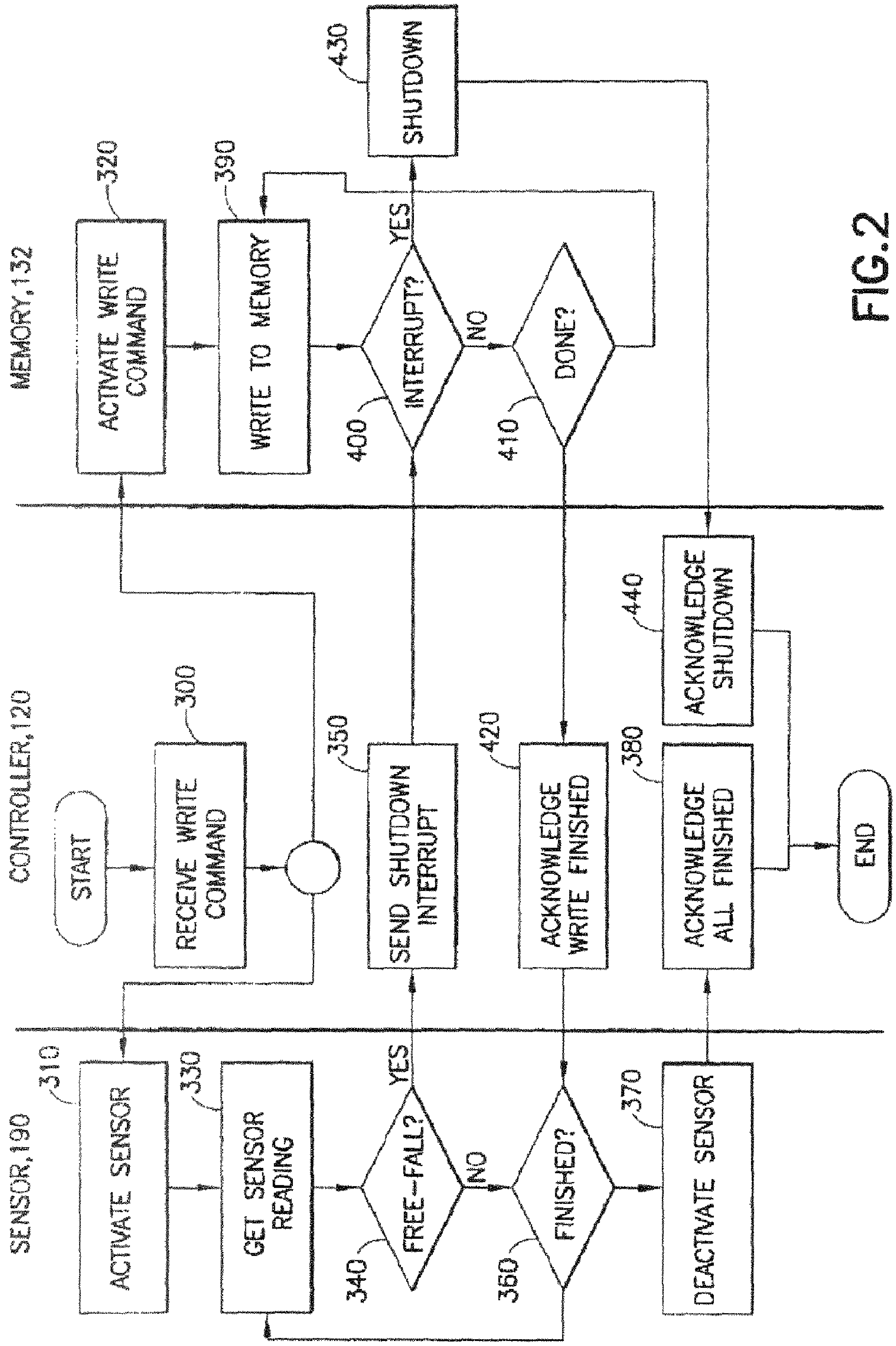

SENSOR,190
CONTROLLER,120
MEMORY,132
START
RECEIVE WRITE COMMAND
300
ACTIVATE SENSOR
310
ACTIVATE WRITE COMMAND
320
GET SENSOR READING
330
FREE-FALL?
340
YES
NO
SEND SHUTDOWN INTERRUPT
350
FINISHED?
360
DEACTIVATE SENSOR
370
ACKNOWLEDGE ALL FINISHED
380
WRITE TO MEMORY
390
INTERRUPT?
400
DONE?
410
ACKNOWLEDGE WRITE FINISHED
420
SHUTDOWN
430
ACKNOWLEDGE SHUTDOWN
440
END

FIG.2

PROTECTION OF NON-VOLATILE MEMORY COMPONENT AGAINST DATA CORRUPTION DUE TO PHYSICAL SHOCK

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation filed under 35 U.S.C. §120 of U.S. patent application Ser. No. 10/888,283 that was filed Jul. 9, 2004, the disclosure of which is incorporated by reference in its entirety.

FIELD

This invention relates generally to data storage memory devices and components and, more specifically, relates to the protection of data stored in a non-volatile memory device during a physical shock to a unit that contains the memory device.

BACKGROUND

All solid state non-volatile memory devices that are known to the inventors, including Flash memory, MultiMedia Card (MMC), and Subscriber Identity Module (SIM), are vulnerable to an abrupt termination of power. As but one example, a file-control system or the memory contents can be corrupted if the power-off occurs during a write sequence, such as during a file-control table update procedure. While this problem can exist in any electronic system that incorporates one or more non-volatile memory devices, the problem is especially acute in handheld portable electronic systems that are subject to frequency handling by the user. Examples of such systems include, but are not limited to, cellular telephones, personal digital assistants (PDAs), portable computers, image capture devices such as digital cameras, gaming devices, music appliances and handheld units or terminals that incorporate combinations of two or more such functions.

The abrupt and unexpected interruption of power can occur when the terminal is dropped due to one or more of a number of occurrences. For example, dropping the terminal can result in the movement or expulsion of the battery, leading to an abrupt and uncontrolled power-off condition. Dropping the terminal may also result in the movement or expulsion of the memory component itself, such as a plug-in memory card. This can also lead to an abrupt and uncontrolled power-off condition, as well as an abrupt termination of the memory component digital input outlines and the signals conveyed thereby.

It is known in the art to provide some protection for rotating magnetic media (a hard disk drive, or HDD). For example, U.S. Pat. No. 5,982,573, entitled "Disk Drive and Method for Minimizing Shock-induced Damage", describes a disk drive having a fall detection control system that detects when the disk drive is in a free fall, and takes precautionary protective action to minimize physical damage from any resulting shock upon impact. The disk drive includes an accelerometer device that measures acceleration of the disk drive along three mutually orthogonal axes x, y, and z, and resolves the measurement into respective vectors. A processor is programmed to compute a net acceleration of the disk drive, compare the net acceleration with a selected acceleration threshold level, measure a duration that the net acceleration exceeds the acceleration threshold level, compare the measured duration with a selected reference time period, and output a warning signal when the measured duration exceeds the reference time period. Upon receipt of the warning signal, a controller initiates protective routines in preparation for shock.

Also of interest is U.S. Pat. No. 6,567,709, "Integrated Monitoring, Diagnostics, Shut-down and Control System"; U.S. Pat. No. 5,991,114 "Disc Drive Having Gram Load Reducer and Method of Operating Gram Load Reducer", and U.S. Pat. No. 5,227,929, "Portable Computer Hard Disk Protective Reflex System".

Prior to this invention, the inventors are not aware of any protective mechanisms or methods for solid state memory devices to avoid data corruption due to an impact after a fall.

SUMMARY

The foregoing and other problems are overcome, and other advantages are realized, in accordance with the presently preferred embodiments of these teachings.

In an exemplary embodiment, a method of operating an electronic device is provided. The method includes, but is not limited to, initiating a write operation of data to a non-volatile memory of an electronic device; during the initiated write operation, monitoring a sensor to determine if the electronic device is falling, and if the electronic device is determined to be failing, interrupting the initiated write operation and executing a non-volatile memory shutdown procedure.

In another exemplary embodiment, a computer-readable medium is provided. The computer-readable medium includes, but is not limited to, computer-readable instructions tangibly stored therein that, upon execution by a processor of an electronic device, cause the electronic device to initiate a write operation of data to a non-volatile memory of the electronic device; during the initiated write operation, to monitor a sensor to determine if the electronic device is falling; and if the electronic device is determined to be falling, to interrupt the initiated write operation and to execute a non-volatile memory shutdown procedure.

In still another exemplary embodiment, a device is provided. The device includes, but is not limited to, a sensor, a processor, a non-volatile memory, and a computer-readable medium. The computer-readable medium includes, but is not limited to, computer-readable instructions stored therein that, upon execution by the processor, perform operations comprising initiating a write operation of data to the non-volatile memory; during the initiated write operation, monitoring the sensor to determine if the electronic device is falling; and if the electronic device is determined to be falling interrupting the initiated write operation and executing a non-volatile memory shutdown procedure.

In yet another exemplary embodiment, a second device is provided. The second device includes, but is not limited to, a sensing means for sensing a free fall condition of the electronic device and a processing means configured to initiate a write operation of data to a non-volatile memory; during the initiated write operation, to monitor the sensing means to determine if the electronic device is falling; and if the electronic device is determined to be falling, to interrupt the initiated write operation and to execute a non-volatile memory shutdown procedure.

Further aspects of this invention relate to a terminal that operates in accordance with the method, and a wireless communications terminal having an accelerometer-based sensor that operates in accordance with the method.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other aspects of these teachings are made more evident in the following Detailed Description of the Preferred Embodiments, when read in conjunction with the attached Drawing Figures, wherein:

FIG. **1** is a block diagram showing a mobile station that is constructed and operated in accordance with this invention; and

FIG. **2** is a logic flow diagram of a method to operate the mobile station of FIG. **1**.

DETAILED DESCRIPTION

FIG. **1** is a simplified block diagram an embodiment of a wireless communications terminal or mobile station **100** in accordance with this invention. It should be noted, however, that this invention applies to many different types of hand-held, portable and other types of terminals, including those that have no wireless communications capability. For example, the terminals that can benefit from the use of this invention include, but are not limited to, cellular telephones, such as the one depicted in FIG. **1**, as well as gaming devices, digital cameras, PDAs, navigation (e.g., GPS) devices, data logging devices, portable bar code scanners, Internet appliances and, in general, any type of electronic equipment that includes at least one non-volatile memory device that is writable during the normal operation of the device. As employed herein a non-volatile memory device can be a device that is designed and engineered to retain data when the system operating power is removed (e.g., Flash memory devices), as well as a volatile memory device (e.g., a static RAM) that is packaged or otherwise connected to a separate backup battery or a charge storage capacitor.

The mobile station **100** typically includes a control unit or control logic, such as a microcontrol unit (MCU) **120** having an output coupled to an input of a display **140** and an input coupled to an output of a keyboard or keypad **160**. The mobile station **100** may be a handheld radiotelephone, such as a cellular telephone or a personal communicator.

The MCU **120** is assumed to include or be coupled to some type of a memory, including a non-volatile memory (NVM) **132** for storing an operating program and other information, as well as a volatile memory **130** for temporarily storing required data, scratchpad memory, received packet data, packet data to be transmitted, and the like. The operating program is assumed, for the purposes of this invention, to enable the MCU **120** to execute the software routines, layers and protocols required to implement the methods in accordance with this invention, as well as to provide a suitable user interface (UI), via display **140** and keypad **160**, with a user. Although not shown, a microphone and speaker are typically provided for enabling the user to conduct voice calls in a conventional manner.

Although not germane to an understanding of this invention, the mobile station **100** also contains a wireless section that includes a digital signal processor (DSP) **180**, or equivalent high speed processor or logic, as well as a wireless transceiver that includes a transmitter **210** and a receiver **220**, both of which are coupled to an antenna **240** for communication with the network operator. At least one local oscillator, such as a frequency synthesizer (SYNTH) **260**, is provided for tuning the transceiver. Data, such as digitized voice and packet data, is transmitted and received through the antenna **240** in accordance with an air interface standard that may conform to any standard or protocol.

The mobile station **100** also includes an free fall sensor, embodied in this non-limiting embodiment as an acceleration sensor **190**, such as an accelerometer that has three sensitive axes. The acceleration sensor **190** is used to detect that the mobile station **100** is falling, and thus senses the acceleration of the mobile station **100** due to gravity. The output of the acceleration sensor **190** is designated as **190**A, while an input signal to the sensor **190** that activates the sensor is designated as Activate **190**B.

The NVM **132** can include a single type of memory, or it may present a plurality of different memory types, such as two or more of Flash memory, MultiMedia Card (MMC) memory and a Subscriber Identity Module (SIM) that contains a non-volatile memory device. Each NVM **132** component is assumed to be responsive to a specified signal with which it is either shut down, put into a sleep mode, or placed into a safe mode in which no corruption of stored data can occur. This signal is shown in FIG. **1** as Control (CNTL) **132**A that is sourced by the MCU **120**. In other embodiments the CNTL signal **132**A could be sourced by the DSP **180**, or by dedicated logic.

When the acceleration sensor **190** detects a free-fall situation, its sends a pre-defined signal to the MCU **120** over signal line **190**A. The MCU **120** in response sends the predefined shutdown signals to each of the NVM **132** components via the Control signal line **132**A.

In a preferred embodiment, the acceleration sensor **190** is only turned on or activated, i.e., placed in a full power mode of operation with Activate signal **190**B, when a write operation is being performed to one of the NVM **132** components. In this way a power savings is realized, as the mobile station **100** will typically be powered by an internal battery (not shown).

Referring to FIG. **2**, at Block **300** the controller (MCU) **120** receives (or originates) a write command for the NVM **132**. In response the MCU **120** activates in Block **310** the sensor **190** via signal line **190**B, and also activates a write memory command to the NVM **132** (Block **320**). Continuing for convenience at the acceleration sensor **190**, at Blocks **330**, **340** and **360**, a sensing loop is executed to get the sensor reading and determine if a free fall condition (shock) is indicated. The loop is executed until the NVM **132** write operation is indicated as being finished by the output of Block **420** or a free fall condition has been indicated. If a free fall condition is indicated, Block **340** transitions to Block **350** to send a shutdown interrupt (CNTL **132**A) to the NVM **132**. Assuming that the write operation concludes normally, Block **360** transitions to Block **370** to deactivate the acceleration sensor **190** via signal line **190**B, and then transitions to Block **380** to acknowledge completion.

At the NVM **132**, in response to the activation of the write command at Block **320**, the data is written to the memory at Block **390**, and a loop **390**, **400**, **410** is executed until the NVM write operation is signaled as being completed at Block **410**. Block **410** sends the completion signal to controller block **420**, which sends the acknowledgment of the write operation being completed to Block **360** of the sensor **190**. The write loop Block **400** tests to see if the shut down interrupt has been generated by the controller Block **350** (CNTL **132**A is asserted). If the shut down interrupt is generated, then Block **400** transitions to Block **430** to terminate the write operation, and execute the shutdown procedure that is specific to the NVM **132**. For example, and depending on the type of NVM, the shutdown procedure can entail actually shutting off the NVM **132**, or putting the NVM **132** into a sleep (low power consumption) mode, or otherwise placing the NVM **132** into some type of safe mode in which no corruption of stored data is likely to occur. In some embodiments the safe mode may simply be an idle mode, where no active read or write operation is occurring. Block **430** may then transition to controller Block **440** to acknowledge the NVM **132** shutdown has occurred, and the method ends.

During the use of the preferred embodiments of this invention some variations to the foregoing methods can be made. For example, in response to receiving the write command at Block **300**, the controller **120** may first check the free fall sensor at **340** to ensure that a free fall condition is not currently indicated before executing a transition to block **320** to activate the write command. Further by example, for those storage technologies where the NVM **132** should be actively shut down after sensing a free fall condition, such as when using a hard disk drive (HHD), the method shown in FIG. **2** may be used as well for read operations, and not just for write operations.

It is preferred to partition critical data into small enough portions that a write operation can be accomplished during the free fall time.

It is also within the scope of this invention for the MCU **120** to optimize the sampling frequency (and hence power consumption) of the acceleration sensor **190** when a drop threshold is known, as described below.

A suitable free fall detection method is as follows (Blocks **330**, **340**, **360** of FIG. **2**). During free fall, the acceleration is always one g. Thus the acceleration sensor **190** output can be activated when the measured acceleration reaches a predetermined level (such as 0.4-1 g due to the need to account for sensor errors). The time of free fall is measured, giving the distance fallen as $x(t)=g*t^2/2$. A threshold time of free fall is preferably made as long as possible, to allow vibrations to be distinguished from a free fall. When the measured x(t) exceeds the predefined threshold **X0**, the Control signal **132**A is asserted to the NVM **132** to place the NVM(s) **132** into a state where the corruption of stored data is unlikely, should the mobile station experience an impact on a hard surface (Block **430** of FIG. **2**).

In the prior art a time threshold of about 125 msec is known to correspond to a drop of about seven centimeters, which is suggested as a threshold for initializing a HDD protection mechanism.

However, for a mobile terminal, such as the mobile station **100**, the thresholds of interest are somewhat different. A standard mobile station **100** drop test height is 1.5 m. Because of the acceleration, the threshold time (T) increases mores slowly than the altitude (X), namely:

X0	T0
0.5 m	320 msec
1 m	450 msec
1.5 m	550 msec

Assume that the maximum time required to activate the NVM **132** shutdown sequence is TM. An exact value for TM can be difficult to determine, due to the requirements of different NVM **132** technologies. However, for an exemplary MMC card the value of TM is in the range of a few tens of milliseconds. Thus, a non-limiting and exemplary value of 100 ms is used below.

Let the sampling period of the acceleration sensor **190** be FS Hz, which means that the acceleration is sampled once every TS=1/FS seconds. There is thus a "dead time" of TM+1/FS seconds. Thus, the actual threshold time TT available for the measurement of free fall becomes:

$$TT=T0-TM-TS=\text{sqrt}(2*x0/g)-TM-1/FS.$$

This allows a minimum value for FS to be defined, when it is desired that TT be above a defined minimum TTMIN in order to eliminate spurious effects. Thus, the sampling of the acceleration sensor **190** during a NVM **132** write operation can be optimized to conserve battery power.

As a numerical example: assume that TTMIN=100 msec is a sufficient amount of time, assume that TM=100 msec, and assume that the drop height threshold is one meter, then TT>TTMIN=0.1 s=0.45 s−0.1 s−1/FS, which means that an acceleration sensor **190** sampling frequency of 4 Hz is adequate. If the acceptable drop altitude is increased to 1.5 m, then the sampling frequency can be 2.9 Hz, while a reduced 0.5 m drop height requires a 8.3 Hz sampling frequency.

This variability allows the use of an optional feature in the basic drop detection NVM **132** shutdown algorithm: i.e., if there are large variations between the TM for various NVM **132** components, then a Sensor Activation flag (Activate Sensor Block **310** of FIG. **2**) can include the TM for the NVM **132** component which launched the sensor (or the required sampling rate directly). That is, the acceleration sensor **190** sampling rate can be made adaptive, and established at Block **310** depending on which NVM **132** component the write operation is being performed to. This allows the sampling rate to be minimized to accommodate the specific NVM component which is to be protected. For example, and assuming the case of a one meter drop distance: if TM=0.1 s, then FS=4.0 Hz (as above); if TM=0.05 s, then FS=3.3 Hz, and if TM=0.01 s, then FS=2.9 Hz.

The resulting approximately 30% reduction in sampling rate (and roughly the same in power consumption) can be quite significant in the mobile station **100**.

The use of this invention is advantageous in that it minimizes the chance for the corruption of NVM data due to inadvertently dropping the mobile station **100**. This is especially advantageous in the case of memory cards, such as a SIM card, that can be reused in another mobile station or terminal in the event that the dropped mobile station is damaged.

In another embodiment of this invention acceleration sensor **190** sends the free fall signal **190**A directly to each NVM **132**, such as by a shared bus (shown as a dashed line **190**A' in FIG. **1**). While this is a faster operating solution, since the MCU **120** is bypassed, its use implies that either the NVM memory **132** components convert the free-fall signal to a shutdown signal, or that the acceleration sensor **190** generates and transmits the appropriate NVM **132** shutdown signal(s) (CNTL **132**A).

Based on the foregoing description it should be apparent that a non-limiting aspect of this invention is a computer program embodied on a computer readable storage medium, such as the memory **130** in FIG. **1**, that is comprised of instructions to direct a computer, such as the MCU **120** in FIG. **1**, that is embodied in an enclosure, such as the mobile station **100**, to be responsive to initiating an operation such as read operation, a write operation, or a read/modify/write operation, with a non-volatile memory device **132** to activate a sensor **190** that is capable of detecting that the enclosure is falling. During the operation the instructions direct the computer to monitor the sensor to determine if the enclosure is falling and, if it is determined that the enclosure is falling, to terminate the operation and to execute a non-volatile memory shutdown procedure. If it is determined instead that the enclosure is not falling, the operation is completed and the sensor is deactivated.

Monitoring can include operating the sensor at a sampling rate that is selected based on the type of non-volatile memory device that the operation is directed to; or operating the sensor at a sampling rate that is selected based on an amount of time required to execute the non-volatile memory device shutdown procedure, or operating the sensor at a sampling rate that is selected based on a predetermined minimum threshold distance over which the enclosure can fall; or operating the sensor at a sampling rate that is selected to minimize sensor power consumption within constraints imposed by at least one characteristic of the non-volatile memory device that the operation is directed to. The sensor may be operated at a sampling rate that is based on more than one of these criteria, either alone or in combination with even further criteria.

The foregoing description has provided, by way of exemplary and non-limiting examples, a full and informative description of the best method and apparatus presently contemplated by the inventors for carrying out the invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. As but some examples, the use of other types of free fall sensors, such as a barometer/altimeter or a proximity sensor (acoustic or optical), may occur to those skilled in the art, as may also the use of other types of NVM **132** components. However, all such and similar modifications of the teachings of the preferred embodiments of this is invention will still fall within the scope of this invention.

Furthermore, some of the features of the present invention could be used to advantage without the corresponding use of other features. As such, the foregoing description should be considered as merely illustrative of the principles of the present invention, and not in limitation thereof.

What is claimed is:

1. A method comprising:

initiating a write operation of data to a solid-state memory device of an electronic device;

during the initiated write operation, monitoring a sensor to determine if the electronic device is accelerating, wherein the monitoring occurs at a sampling rate selected based on at least one of a type of the solid-state memory device, an amount of time to execute a solid-state memory device shutdown procedure, or a threshold distance over which the electronic device can move; and

if the electronic device is determined to be accelerating, interrupting the initiated write operation and executing the solid-state memory device shutdown procedure.

2. The method of claim **1**, wherein the sensor is further monitored at a sampling rate selected to minimize sensor power consumption within constraints imposed by at least one characteristic of the solid-state memory device.

3. The method of claim **1**, further comprising, before initiating the write operation, checking the sensor to determine if the electronic device is accelerating.

4. The method of claim **1**, further comprising, before initiating the write operation, partitioning the data into one or more memory segments, wherein a size of the one or more memory segments is selected based on an acceleration time.

5. The method of claim **1**, further comprising:

initiating a read operation of data from the solid-state memory device;

during the initiated read operation, monitoring the sensor to determine if the electronic device is accelerating; and

if the electronic device is determined to be accelerating, interrupting the initiated read operation and executing the solid-state memory device shutdown procedure.

6. The method of claim **1**, wherein the solid-state memory device is comprised of at least one of a flash memory device, a multimedia card, and a subscriber identity module.

7. The method of claim **1**, wherein the electronic device is one of a mobile telephone, a gaming device, a digital camera, a personal digital assistant, a navigation device, a data logging device, a portable bar code scanner, and an Internet appliance.

8. The method of claim **1**, wherein the sensor is selected from the group consisting of an acceleration sensor, a barometer, an altimeter, an acoustic proximity sensor, and an optical proximity sensor.

9. A computer-readable storage medium having stored thereon computer-executable instructions that, if executed by an electronic device, cause the electronic device to perform a method comprising:

initiating a write operation of data to a solid-state memory device of the electronic device;

during the initiated write operation, monitoring a sensor to determine if the electronic device is accelerating, wherein the monitoring occurs at a sampling rate selected based on at least one of a type of the solid-state memory device, an amount of time to execute a solid-state memory device shutdown procedure, or a threshold distance over which the electronic device can move; and

if the electronic device is determined to be accelerating, interrupting the initiated write operation and execute the solid-state memory device shutdown procedure.

10. The computer-readable storage medium of claim **9**, wherein the sensor is further monitored at a sampling rate selected to minimize sensor power consumption within constraints imposed by at least one characteristic of the solid-state memory device.

11. The computer-readable storage medium of claim **9**, wherein the instructions are further configured to cause the electronic device to check the sensor to determine if the electronic device is accelerating before initiating the write operation.

12. The computer-readable storage medium of claim **9**, wherein the instructions are further configured to cause the electronic device to partition the data into one or more memory segments before initiating the write operation, wherein a size of the one or more memory segments is selected based on an acceleration time.

13. The computer-readable storage medium of claim **9**, wherein the instructions are further configured to cause the electronic device to:

initiate a read operation of data from the solid-state memory device;

during the initiated read operation, monitor the sensor to determine if the electronic device is accelerating; and

if the electronic device is determined to be accelerating, interrupt the initiated read operation and execute the solid-state memory device shutdown procedure.

14. An electronic device comprising:

a sensor;

a processor;

a solid-state memory device; and

a computer-readable storage medium including computer-readable instructions stored therein that, upon execution by the processor, perform operations comprising

initiating a write operation of data to the solid-state memory device;

during the initiated write operation, monitoring the sensor to determine if the electronic device is accelerating, wherein the monitoring occurs at a sampling rate selected based on at least one of a type of the solid-state memory device, an amount of time to execute a solid-state memory device shutdown procedure, or a threshold distance over which the electronic device can move; and if the electronic device is determined to be accelerating, interrupting the initiated write operation and executing the solid-state memory device shutdown procedure.

15. The electronic device of claim **14**, wherein the computer-readable medium includes the solid-state memory device.

16. The electronic device of claim **14**, wherein the sensor is further monitored at a sampling rate selected to minimize sensor power consumption within constraints imposed by at least one characteristic of the solid-state memory device.

17. The electronic device of claim **14**, wherein the instructions are further configured to cause the electronic device to check the sensor to determine if the electronic device is accelerating before initiating the write operation.

18. The electronic device of claim **14**, wherein the instructions are further configured to cause the electronic device to partition the data into one or more memory segments before initiating the write operation, wherein a size of the one or more memory segments is selected based on an acceleration time.

19. The electronic device of claim **14**, wherein the instructions are further configured to cause the electronic device to:

initiate a read operation of data from the solid-state memory device;

during the initiated read operation, monitor the sensor to determine if the electronic device is accelerating; and

if the electronic device is determined to be accelerating, interrupt the initiated read operation and execute the solid-state memory device shutdown procedure.

20. An electronic device comprising:

a sensing means for sensing an acceleration condition of the electronic device; and a processing means configured to initiate a write operation of data to a solid-state memory device;

during the initiated write operation, monitor the sensing means to determine if the electronic device is accelerating, wherein the monitoring occurs at a sampling rate selected based on at least one of a type of the solid-state memory device, an amount of time to execute a solid-state memory device shutdown procedure, or a threshold distance over which the electronic device can move; and

if the electronic device is determined to be accelerating, interrupt the initiated write operation and execute the solid-state memory device shutdown procedure.

21. The electronic device of claim **20**, wherein the processing means is further configured to check the sensor to determine if the electronic device is accelerating before initiating the write operation.

22. The electronic device of claim **20**, wherein the processing means is further configured to partition the data into one or more memory segments before initiating the write operation, wherein a size of the one or more memory segments is selected based on an acceleration time.

23. The method of claim **1**, wherein the electronic device is determined to be accelerating due to falling.

24. The computer-readable medium of claim **9**, wherein the electronic device is determined to be accelerating due to falling.

25. The electronic device of claim **14**, wherein the electronic device is determined to be accelerating due to falling.

26. The electronic device of claim **20**, wherein the electronic device is determined to be accelerating due to falling.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,015,444 B2
APPLICATION NO. : 11/955839
DATED : September 6, 2011
INVENTOR(S) : Makela et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page, item (57), under “Abstract”, in Column 2, Line 1, delete “computer readable” and insert -- computer-readable --.

Column 8, line 25, in Claim 10, delete “The computer-readable” and insert -- A computer-readable --.

Column 8, line 30, in Claim 11, delete “The computer-readable” and insert -- A computer-readable --.

Column 8, line 36, in Claim 12, delete “The computer-readable” and insert -- A computer-readable --.

Column 8, line 42, in Claim 13, delete “The computer-readable” and insert -- A computer-readable --.

Column 10, line 26, in Claim 24, delete “The computer-readable medium” and insert -- A computer-readable storage medium --.

Signed and Sealed this
Twenty-fourth Day of April, 2012

David J. Kappos

David J. Kappos
Director of the United States Patent and Trademark Office